Oct. 6, 1959 W. SCHWENK 2,907,239

ROTARY IMPACT TOOL

Filed Jan. 7, 1958 2 Sheets-Sheet 1

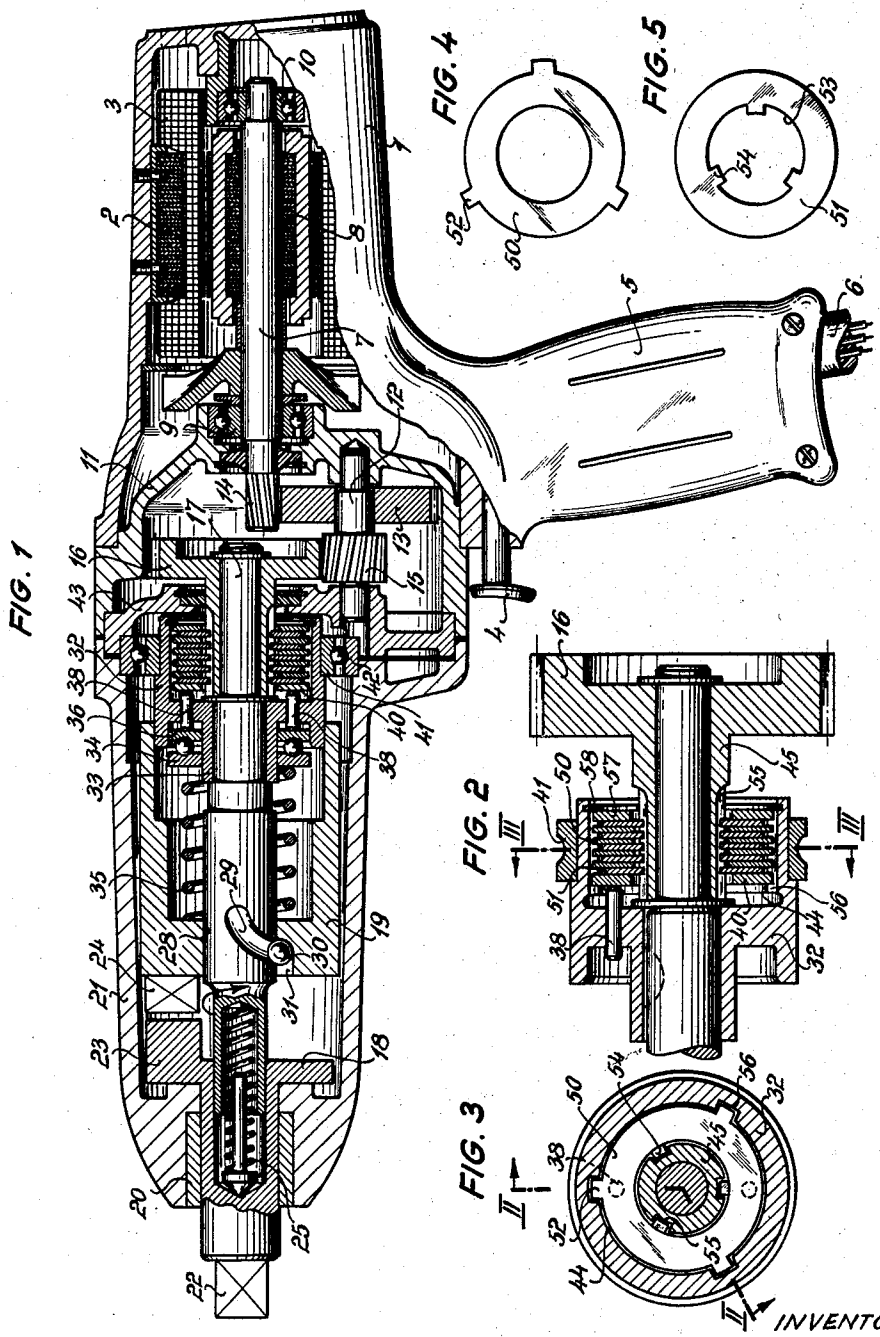


FIG. 1

FIG. 4

FIG. 5

FIG. 2

FIG. 3

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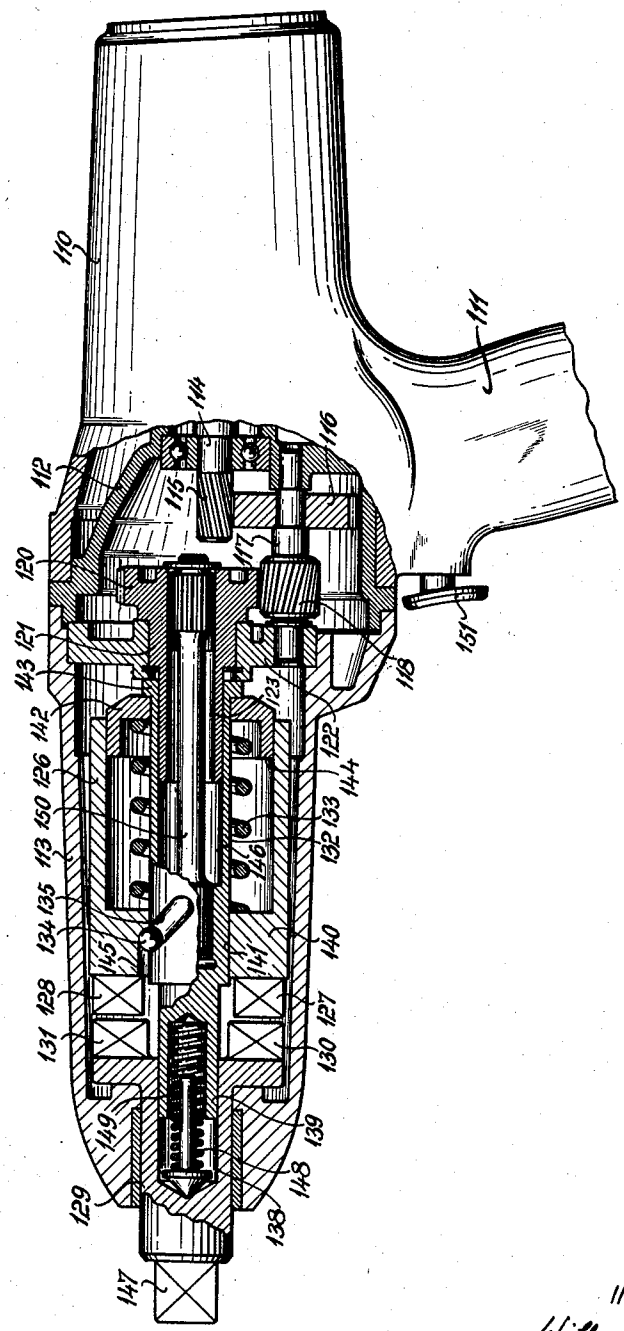
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FIG. 6



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2,907,239

Patented Oct. 6, 1959

2,907,239

ROTARY IMPACT TOOL

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Application January 7, 1958, Serial No. 707,596

Claims priority, application Germany January 8, 1957

10 Claims. (Cl. 81—52.3)

The present invention relates to power tools.

More particularly, the present invention relates to power tools which are adapted to turn elements such as screws, bolts and the like not only with a steady continuous turning force but also with rotary impact forces when the workpieces such as the bolts or the like encounter resistances to turning.

Conventional power tools of this type are subjected to severe stresses resulting from the rotary impact forces, and it does not infrequently happen that parts of such power tools, such as parts of the motors thereof, break or otherwise fail due to the impact forces.

One of the objects of the present invention is to provide a power tool of the above type with a structure which will reliably shield the driving motor of the tool from relatively severe forces to which the impact providing structure of the tool is subjected.

Another object of the present invention is to provide a hand power tool of the above type which will operate smoothly and which is capable of being comfortably held by the operator.

A further object of the present invention is to provide a power tool of the above type which is capable of automatically counterbalancing and compensating forces set up by the impact producing structure.

An additional object of the present invention is to provide a power tool capable of accomplishing the above objects and at the same time composed of simple, ruggedly constructed elements which are reliable in operation.

With the above objects in view the present invention includes in a power tool a rotary driven means which is adapted to cooperate at least indirectly with a workpiece for turning the same and a rotary impact means which cooperates with the driven means for turning the same and for driving the driven means with rotary impact blows when the driven means encounters more than a predetermined resistance to turning. The tool of the invention further includes a drive means and, in accordance with the present invention, a yieldable transmission means which cooperates with the drive means and the rotary impact means for transmitting a drive from the drive means to the rotary impact means. The yieldable transmission means of the present invention yields to shield the drive means from relatively severe forces to which the rotary impact means is subjected during operation of the power tool.

The novel features which are considered as characteristic for the invention are set forth in in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a sectional elevational view of one embodiment of a power tool according to the present invention;

Fig. 2 is a sectional elevational view taken along line II—II of Fig. 3 in the direction of the arrows and showing part of the yieldable transmission means of the present invention;

Fig. 3 is a sectional plan view taken along line III—III of Fig. 2 in the direction of the arrows;

Fig. 4 shows one type of slip clutch lamination used in the structure of the present invention;

Fig. 5 shows another type of slip clutch lamination; and

Fig. 6 is a sectional elevational view of another embodiment of a power tool according to the present invention.

Referring to Fig. 1, the hand power tool includes a drive motor housing 1 cast from a light metal such as aluminum, and the stator laminations 2 of an electric motor are fixed in the housing 1. These laminations carry a stator coil 3 capable of being connected electrically through the cable 6 with a source of three phase alternating current upon actuation by the operator of the finger-operated switch 4 which closes a suitable switch located in the handle 5. The motor shaft 7 carries a short circuit armature 8 which turns with the shaft 7 when the coil 3 is energized. The shaft 7 carries the inner races 9 and 10 of a pair of ball bearings whose outer races are supported by the right end wall of the housing 1, as viewed in Fig. 1, and by the cover 11 of the housing 1, respectively, this cover 11 being fixed to and extending into the housing 1 through the left open end thereof, as viewed in Fig. 1.

On the other side of the cover 11 from the driving motor is located a transmission shaft 12 of a transmission means, this shaft 12 fixedly carrying a relatively large gear 13 which meshes with a pinion 14 formed at the left free end of the shaft 7. The shaft 12 is formed with a pinion 15 which meshes with a gear 16 which has an elongated tubular hub portion which receives a portion of the drive shaft 17, the gear 16 being freely turnable with respect to drive shaft 17. The opposite end of the drive shaft 17 extends slidably into an axial bore of a rotary driven means 18 which is freely turnable with respect to the drive shaft, so that the driven means 18 and gear 16 serve as bearings for the drive shaft 17. A rotary impact means 19 is formed with a bore 28 through which the drive shaft 17 also slidably extends. Thus, the rotary driven means 18 and rotary impact means 19 are freely rotatable and axially shiftable on the shaft 17.

The driven means 18 is supported for rotation by a brass bearing sleeve 20 carried by a housing portion 21 between which and the housing 1 the cover 11 is clamped. Thus, the housing 21 forms together with cover 11 and housing 1 a support means for the structure of the invention. The driven means 18 has an outer end provided with an end portion 22 of square cross section adapted to cooperate with an unillustrated socket wrench which in turn cooperates with a bolt or the like for transmitting the turning of the driven means 18 to such a bolt. The opposite end of the driven means 18 forms the driven half of a dog clutch and is provided with a clutch dog 23. The end of the rotary impact means 19 which is directed toward the driven means 18 forms the driving half of the dog clutch and has a clutch dog 24 which cooperates with the dog 23. A coil spring 25 in the bore of driven means 18 and in a communicating bore of the drive shaft 17 urges the driven means 18 to the rest position thereof shown in Fig. 1. When the operator presses the tool to the left, as viewed in Fig. 1, the spring 25 becomes compressed and the housing 21 shifts to the left along the driven means 18 to cause the halves of the dog clutch to come into mesh with each other.

The rotary impact means 19, except for its left end wall which is formed with the bore 28, is of tubular configuration, and the annular surface which defines the bore 28 is formed with a recess 31 directed toward the axis of bore 28. The recess 31 is in the form of an axial groove. The outer surface of drive shaft 17 is formed with a helical groove 29 inclined at approximately 45° to the axis of shaft 17 and having a part directed toward the recess 31. A motion transmitting element in the form of a spherical ball member 30 is located partly in the groove 29 and partly in the recess 31.

A sleeve 32 coaxially surrounds the shaft 17 and extends slidably into the open end of the rotary impact means 19, and this sleeve 32 has a reduced tubular end portion keyed to the shaft 17, so that the sleeve 32 rotates with the shaft 17. The reduced portion 33 of the sleeve 32 axially guides the races 34 and 36 of a thrust bearing, and the right end of a coil spring 35, as viewed in Fig. 1, abuts against the race 34. The other race 36 engages a pair of push pins 38 which are parallel to shaft 17 and arranged at diametrically opposed sides thereof. These pins extend slidably through a pair of bores, respectively, formed in an annular wall portion of sleeve 32. The ends of the pins 38 distant from race 36 abut against a pressure ring 40. The outer surface of the sleeve 32 is provided with a shoulder which carries the inner race 41 of a ball bearing, the outer race 42 of which is carried in part by the housing 21 and in part by a partition 43 between wall 11 and housing 21.

As is apparent from Figs. 2 and 3 the elongated tubular hub portion 45 of gear 16 extends into and is surrounded by the sleeve 32. In the space between the tubular hub portion 45 and the inner surface 44 of sleeve 32 are located four annular slip clutch laminations 50 and five slip clutch laminations 51 of a slightly smaller outer diameter than the laminations 50. Each of the laminations 50 is provided at its outer periphery with three projections 52 spaced 120° apart from each other while each of the laminations 51 is provided at its inner periphery with three projections 54 also spaced 120° apart from each other. The inner peripheries 53 of the laminations 51 as well as the inner peripheries of the laminations 50 surround the tubular hub portion 45, and the two sets of laminations are arranged with the laminations of one set alternating with those of the other set. The projections 54 extend into axial grooves 55 formed in the hub portion 45 while projections 52 extend into axial grooves 56 formed at the inner surface 44 of sleeve 32. An end ring 57 is located in sleeve 32 and prevented from moving out of the same by a snap ring 58.

In order to guarantee that the above-described transmission means will transmit the drive from the motor to the rotary impact means even in the rest position of the parts shown in Fig. 1, the length and compression of the spring 35 in the position of the part shown in Fig. 1 is sufficient to enable this spring to act through the thrust bearing 34, 36 and push pins 38 to maintain the slip clutch laminations 50 and 51 in sufficient frictional engagement with each other for transmitting the drive from gear 16 to shaft 17.

The above-described structure operates as follows:

As was mentioned above, when the operator presses on the tool the dog clutch halves will mesh. The compressed spring 35 will hold the rotary impact means 19 in its illustrated operating position with the ball 30 located at the left end of the inclined groove 29. Thus, the drive is transmitted from shaft 17 through element 30 to impact means 19 and by engagement of dogs 24 and 23 to the driven means 18. In this way rotation of the driven means 18 will continue until the driven means encounters a predetermined resistance to turning which is great enough to prevent the rotary impact means from turning together with the drive shaft 17 so that the latter turns ahead of the impact member 19. At the moment when the rotary impact member 19 stops turning with shaft 17 the ball 30 rides along the groove 29 to shift the driving half of the dog clutch together with the remainder of the rotary impact means axially away from the operating position shown in Fig. 1 to an inoperative disengaged position while simultaneously compressing the spring 35 further. Once the dog 24 slips past the dog 23 the spring 35 expands and shifts the impact member 19 back to its operating position while cooperation of ball 30 and groove 29 accelerate the angular turning of the impact member so that it catches up with the shaft 17, and after reaching its operating position the continued turning of the impact member 19 causes its dog 24 to strike against the dog 23 to provide an impact blow whose energy is transmitted to the head of the workpiece such as a screw or the like which is being turned. This workpiece is thus turned further while absorbing the force of the rotary impact blow. Then the above operations are repeated.

Inasmuch as the rotary impact means is sharply braked at each impact, the shaft 17 is loaded or stressed in a spasmodic, jerky manner as soon as the ball member 30 again cooperates with the groove 29 to accelerate the impact member 19 in the axial direction. This spasmodic stress is to a very great extent shielded from the gear train 13—16 and the armature of the driving motor by momentary slipping of the slip clutch in the sleeve 32, so that the structure provides between the driving motor and the drive shaft 17 a yieldable transmission means capable of yielding to prevent severe forces from being transmitted back through the transmission means to the driving motor.

A particular advantage of the above described structure resides in the plurality of functions performed by the spring 35. Not only does this spring urge the rotary impact member 19 to its operating position but this spring additionally serves to press the slip clutch laminations against each other. Moreover, the spring 35 is in its least compressed condition at impact between the clutch dogs 24 and 23 so that the least pressure is exerted on the slip clutch elements at this time. As the drive shaft 17 continues to turn immediately after impact the spring 35 becomes compressed to an increasing extent so as to gradually increase the pressure with which the slip clutch laminations engage each other so as to guarantee on the one hand transmission of the drive through the transmission means from the driving motor to the drive shaft and on the other hand to provide a smoothly operating tool.

The embodiment of the invention which is illustrated in Fig. 6 is similar to that of Fig. 1 except for the yieldable part of the transmission means. Referring to Fig. 6, the tool illustrated includes a motor housing 110 connected to a handle 111 and closed by a cover 112 whose periphery is clamped between the motor housing 110 and the housing 113. The motor within the housing 110 is similar to that of Fig. 1 and includes an armature shaft 114 formed with a pinion 115 at its free end. The pinion 115 meshes with a gear 116 fixedly carried by the transmission shaft 117 which is provided with a pinion portion 118 which meshes with a gear 120 having an elongated tubular hub portion 123 and adjacent the teeth of the gear 120 a cylindrical portion 121 rotatable in a bearing of the partition 122, the gears 115, 116, 118 and 120 forming part of the transmission means.

The rotary impact means 126 is arranged in the housing 113 coaxially with gear 120 and has a left relatively thick portion 140 which forms with the dogs 127 and 128 integral therewith the driving half of a dog clutch adapted to cooperate with the driven half of the dog clutch formed by the right part of the rotary driven means 129 and including the clutch dogs 130 and 131. When the two clutch halves mesh the clutch dogs have

sufficient angular clearance to permit the driving clutch half to turn freely through a predetermined angle before striking against the driven half of the clutch.

The rotary impact member **126** is formed in portion **140** thereof with an axial bore **141** through which the drive shaft **132** slidably extends, and a coil spring **133** is coiled about the drive shaft **132** and serves as a spring means for urging the rotary impact member **126** to the operating position shown in Fig. 6. The annular surface which defines the bore **141** is formed with a recess **145** in the form of an axial groove, receiving part of transmission element **134** in the form of a ball member, the other part of which extends into the inclined groove **135** formed in the drive shaft **132**, part of the inclined groove always being directed toward the recess **145**. The drive shaft **132** is formed with an axial bore **146** open at the right end of the drive shaft and slidably receiving through this open right end the elongated tubular hub portion **123** of the gear **120**. In this way the hub portion **123** serves as one bearing for the drive shaft **132**, and the other bearing is formed by the axial bore **138** of the driven means **129** which slidably receives the reduced portion **139** of the drive shaft.

A ring **142** is freely shiftable on the drive shaft, and the right end of spring **133** bears against this ring. The ring **142** is pressed by the spring **133** against an integral collar portion **143** of the shaft **132**. The ring **142** has a cylindrical periphery **144** slidably engaging the inner surface of the tubular portion of the rotary impact member **126**. In this way the ring **142** serves to guide the rotary impact member **126** at its end distant from the wall **140**.

A coil spring **148** is located in the communicating axial bores **138** and **149** of the driven means **129** and drive shaft **132**, respectively, and serves as a spring means for yieldably holding the driven means **129** in its illustrated rest position.

In order to transmit the drive from gear **120** to the drive shaft **132**, there is provided in the embodiment of Fig. 6, in accordance with the present invention, a torsion bar **150** having enlarged ends which are respectively splined to the gear **120** and the drive shaft **132** in the manner shown in Fig. 6, and the splined connection is such that the shaft **132** is capable of shifting axially with respect to the torsion bar **150**, the latter carrying at its right end a washer which rests on the right face of gear **120**, as viewed in Fig. 6, so that the torsion bar **150** cannot move to the left beyond the position shown in Fig. 6.

The embodiment of Fig. 6 is set into operation by actuation of the finger switch **151** which closes the circuit to the motor, and, of course, a socket wrench connected to the end portion **147** of square cross section of the driven means **129** cooperates with a bolt or the like to be turned. When the operator presses to the left to compress the spring **148**, the driven clutch half will move into mesh with the driving clutch half, and the tool will turn the screw until there is sufficient resistance to prevent the rotary impact means **126** from turning together with the drive shaft. The latter then continues to turn, and element **134** cooperates with groove **135** to move the impact member **126** to the right, as viewed in Fig. 6, to an inoperative position, while the spring **133** is simultaneously compressed to an increasing extent. After the clutch dogs **127** and **128** become disengaged from and ride over the dogs **130** and **131**, the spring **133** expands so as to axially shift the rotary impact member **126** back to its operating position while simultaneously angularly accelerating the impact member so that it catches up with the drive shaft **132**, and then the driving clutch half engages the driven clutch half with a rotary impact blow whose energy is transmitted to the workpiece. The shock at impact is absorbed to a very large extent by the torsion bar **150** which prevents the severe forces from being transmitted back to the driving motor. The above cycle of operations is repeated twice during each revolution with the embodiment of Fig. 6 and once during each revolution with the embodiment of Fig. 1. It is apparent that the embodiment of Fig. 6 also provides a yieldable transmission means which includes a torsion bar rather than a slip clutch to prevent transmission of severe forces back to the driving motor.

A further advantage of the embodiment of Fig. 6 is that the drive shaft **132**, the spring **133**, and the rotary impact means **126** form a self-contained system supported by the bearings provided by hub portion **123** and bore **138** in cooperation with the drive shaft and axially shiftable in a downward direction, as viewed in Fig. 6, while compressing the spring **148**. As was mentioned above in connection with Fig. 1, during expansion of the spring **133** to shift the rotary impact means back to its operating position, the rotary impact means accelerates in a jerky, spasmodic manner, and the stresses set up by this action are compensated in the embodiment of Fig. 6 by momentary shifting of the drive shaft to the left as viewed in Fig. 6, while compressing the spring **148**, which immediately thereafter expands to return the drive shaft to the axial position shown in Fig. 6.

This operation guarantees quiet running of the machine and enables it to be comfortably handled by the operator as a result of the smooth operation.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of power tools differing from the types described above.

While the invention has been illustrated and described as embodied in rotary power tools, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A power tool comprising, in combination, support means; rotary driven means having an axis of rotation and supported by said support means for rotational and axial movement with respect to said axis, said driven means having an outer exposed end adapted to cooperate at least indirectly with a workpiece to be turned by the power tool and an opposite end in the form of the driven half of a dog clutch; a rotary impact member coaxial with said driven means and having a driving end in the form of the driving half of said dog clutch directed toward and located adjacent said driven half of said dog clutch, said rotary impact member being formed with an axial bore defined by an annular surface formed with a recess directed toward the axis of said impact member; first spring means cooperating with said driven means for yieldably maintaining the latter in an outer rest position, said driven means being axially shiftable by the operator against the force of said first spring means inwardly to an operating position where the driving and driven halves of said dog clutch mesh for transmitting a drive from said rotary impact member to said rotary driven means, said clutch halves having one with respect to the other an angular clearance providing free turning of said driving clutch half with respect to said driven clutch half until said driving clutch half strikes said driven clutch half to

impart a rotary impact blow thereto; a drive shaft extending slidably through said axial bore of said impact member coaxially with the latter and said rotary driven means, said drive shaft being formed with a helical groove, part of which is directed toward said recess of said impact member; a motion transmitting element located partly in said recess and partly in said groove for transmitting rotation of said drive shaft to said impact member and for moving along said groove to shift said rotary impact member away from said rotary driven means when the resistance to turning of the latter is great enough to prevent said driving clutch half from turning at the same speed as said drive shaft, said groove being long enough to provide with said motion transmitting element an axial movement of said driving clutch half to a position out of driving engagement with said driven clutch half when said driven means encounters said resistance; second spring means cooperating with said rotary impact member for urging the latter toward said driven means and for yieldably resisting movement of said driving clutch half out of engagement with said driven clutch half; a driving motor carried by said support means; and yieldable transmission means connecting said driving motor with said drive shaft for rotating the latter, said transmission means yielding to shield said driving motor from relatively severe forces to which said rotary impact member is subjected during operation of the power tool.

2. A power tool as recited in claim 1 and wherein said yieldable transmission means includes a slip clutch which slips to absorb said relatively severe forces and prevent them from being transmitted back to said driving motor.

3. A power tool as recited in claim 1 and wherein said yieldable transmission means includes a torsion bar which twists to absorb said relatively severe forces and prevent them from being transmitted back to said driving motor.

4. A power tool as recited in claim 1 and wherein said yieldable transmission means includes two sets of slip clutch laminations arranged with the laminations of one set alternating with those of the other and being in frictional engagement therewith, said sets of laminations being respectively connected with said driving motor and drive shaft through additional parts of said transmission means for frictionally transmitting the drive from said driving motor to said drive shaft, said sets of laminations slipping with respect to each other to absorb said relatively severe forces and prevent them from being transmitted back to said driving motor.

5. A power tool as recited in claim 4 and wherein said second spring means acts on said laminations for urging them against each other and for maintaining them in frictional engagement.

6. A power tool as recited in claim 4, a thrust bearing located between said second spring means and slip clutch laminations and urged by said second spring means toward said laminations and a plurality of push pins located between and engaging said thrust bearing and the end lamination nearest thereto so that said second spring means acts through said thrust bearing and pins for maintaining said laminations in frictional engagement with each other.

7. A power tool as recited in claim 1 and wherein said yieldable transmission means includes a sleeve coaxially surrounding and spaced from said shaft and having an end portion of reduced diameter fixed thereto, so that said sleeve rotates with said drive shaft, said sleeve having an inner surface directed toward said shaft and formed with an axial groove; said yieldable transmission means also including a gear coaxial with said drive shaft and having an elongated tubular hub portion in which part of said shaft is freely turnable, said hub portion extending into said sleeve and having an outer surface formed with an axial groove directed toward said inner sleeve surface, a plurality of annular slip clutch laminations located next to each other in said sleeve surrounding said tubular hub portion, a plurality of said laminations having outer projections located in said groove of said sleeve and a second plurality of laminations alternating with said first-mentioned plurality of laminations, frictionally engaging the same, and having inner projections located in said hub groove, said second spring means acting on said laminations for urging the same together so as to maintain them in frictional engagement and said driving motor driving said gear and said sleeve and drive shaft through said laminations, the latter slipping to prevent said severe forces from being transmitted back to said driving motor.

8. A power tool as recited in claim 1, said yieldable transmission means including a gear train operatively connected with said driving motor and terminating in an end gear coaxial with said drive shaft and a torsion bar coaxial with said end gear and drive shaft and having opposite end portions respectively splined to said end gear and drive shaft so that the latter is driven by said gear train through said torsion bar, the latter yieldably twisting to prevent said severe forces from being transmitted back to said driving motor.

9. A power tool as recited in claim 8, said second spring means being in the form of a coil spring coiled about said drive shaft, acting with one end against said impact member for urging the latter toward said driven means and acting with its opposite end against a portion of said drive shaft, the latter being movable during movement of said driving half of said dog clutch in one axial direction out of engagement with said driven clutch half in an opposite axial direction for opposing forces of said rotary impact member during disengagement of the dog clutch.

10. A power tool as recited in claim 1, said drive shaft having an elongated hollow portion and an open end distant from said driven means and communicating with said hollow portion, and said drive shaft having an outwardly directed annular collar portion, said second spring means being in the form of a coil spring coiled about said drive shaft, acting with one end on said impact member for urging the latter toward said driven means and acting with its other end on said collar portion of said drive shaft, said yieldable transmission means including a gear train connected operatively with said driving motor and terminating in an end gear coaxial with said shaft and having an elongated tubular hub portion extending freely into said hollow portion of said drive shaft through said open end thereof, and a torsion bar located coaxially in said tubular hub portion and hollow portion of said drive shaft, having one end splined to said end gear, and having an opposite end splined to said drive shaft so that said bar twists to prevent said severe forces from being transmitted back to said driving motor.

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